LANDSLIDE
TECHNOLOGY

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New York State Department of Transportation 1280
1220 Washington Avenue, Bldg. 7
Albany, NY 12232-0863 January 31, 2001

Attn: Mr. Wesley P. Moody
Director, Geotechnical Engineering Bureau

Summary Geotechnical Report: Post-construction
SR 443 (Delaware Avenue) Landslide at Normans Kill
Elsmere (Bethlehem), NY

Dear Mr. Moody:

Landslide Technology performed a reconnaissance on December 9, 2000 following the completion of construction of landslide mitigation features. This letter provides a summary of observations and presents opinions on the mitigation measures constructed. The summary reconnaissance addressed the following:

A. Evaluation of the current condition of slide mitigation features.

B. Evaluation of the instrumentation data, including groundwater and inclinometer trends

C. Evaluation of the existing instrumentation system for monitoring long-term performance of the slide mitigation measures.

D. Evaluation of the slopes adjacent to the landslide (downslope of the Hoffman's Jiffy Lube shop and the Albany Medical Center – Corporate Finance building) and their relative impact on the stability of Delaware Avenue.

Background Information

The SR 443 Landslide became noticeably active on Tuesday May 16 2000. By Thursday, the landslide had retrogressed up the slope and undermined a fruit stand business. The outer parking lots / yards of three businesses became engulfed in the landslide. Delaware Avenue (SR 443) is a main link for suburban communities to reach Albany. On May 20, 2000, Landslide Technology began emergency response consultation. Reports were previously prepared regarding the landslide mechanism and approaches to instrumenting and mitigating the slide. The reports were dated June 5 and 26, 2000.

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Construction Measures / Sequence

Emergency measures were started in June, followed by a formal construction contract in July for permanent stream relocation and slide mitigation, which included relocation of the primary water supply pipes for the City of Albany, as well as gas lines. The mitigation measures consisted of:

1. For short-term stability, the headscarp slope was unloaded by sloping the scarp back to within 5 to 10 feet of the roadway curb.

2. The slide toe at the interim stream channel, located to the north of the original stream that was filled with slide debris, was temporarily protected with riprap to control near-term erosion in the event additional storms occurred during permanent mitigation construction.

3. At the time of emergency riprap construction, several trench drains were constructed within the landslide toe mass, connected perpendicular to the stream bank. The intent of the trench drains was to prevent the build-up of groundwater near the surface of the slide toe area, to facilitate construction access and equipment. The trench drains were eventually connected to a lateral drain trench that directed the drained water towards the stream bank located upstream of the landslide. In addition, drainage ditches and pipes were installed to remove surface water and ponds on the slide mass. The concept of providing deep drainage to increase slide drainage effectiveness, using sand-drains or wick-drains, was evaluated but not selected due to time restrictions and cost.

4. The tall headscarp next to Delaware Avenue was partially controlled with an interim rockfill buttress. This measure was necessitated by the public's desire to have at least two lanes of Delaware Avenue re-opened quickly, prior to construction of permanent mitigations. While the interim buttress provided support to the roadway foundation, the buttress weight slightly decreased the level of stability of the overall landslide. No major landslide movement occurred.

5. The primary solution to resolve long-term problems at this landslide was a rockfill placed against the headscarp to buttress the roadway. This required that the lower slide mass be stabilized at the toe (stream channel) to support the buttress. The stabilization of the lower slide consisted of relocating the Normans Kill stream further away from the slide, which allowed placement of fill material (effectively a counterberm) in the interim stream channel and against the slide toe. Note that the original stream channel was filled in by slide debris, which remained in place during and after construction. The existing water conduits and

gas line had to be realigned and replaced in conjunction with stream channel realignment.

6. The new Normans Kill stream channel was constructed with a smooth curvature and lined with riprap to protect against stream bank erosion, particularly along the toe of nearby marginally stable slopes in the stream channel.

7. Placement of fill in the interim stream channel occurred after the new channel was excavated and the stream flow permanently diverted. The interim stream channel adjacent to the slide was first backfilled with granular material (designated Item 41203.06 M, Select Fill). Then the granular material and the trench drains were covered with soil removed from excavations made for the new stream channel. The fill in the interim stream channel area performs as a counterberm that improves slide resistance by adding soil weight. The added soil weight is effectively buoyant weight (because the slide toe area drainage is minimal).

8. After the interim stream channel was filled and provided improved stability to the landslide, the long-term buttress stabilization method for the headscarp area was completed by adding lightweight pumice rock and dressing the slope with soil for subsequent re-vegetation.

Evaluation of Landslide Mitigation Measures

The evaluation of mitigation measures is based on the conditions observed during the December 9th reconnaissance. No stability analyses were performed. Photographs 1 through 18 (attached) show the observed conditions. Photo 1 shows a panoramic view of the landslide from Delaware Avenue looking north to the Normans Kill stream. The subsequent permanent earthwork has generally buried the initial emergency measures. The riprap along the realigned stream channel is now being covered with soil (for non-geotechnical reasons). The counterberm filling of the interim stream channel, in addition to the slide debris in the original stream, has added significantly more resistive weight to the slide toe. The slope of the counterberm surface is gentle to promote surface drainage (about 3% slope), and together with the riprap in the relocated stream channel should provide a stable stream bank. Photos 2, 3, and 4 show various views of the counterberm and realigned stream channel.

The counterberm consists of a granular fill placed within the interim stream channel and a cover of fine-grained soil that is relatively impermeable and covers the trench drains. Groundwater pressures within the slide toe and counterberm are

relatively shallow. There was no evidence of groundwater seepage on the counterberm slope at the time of our visit.

The final buttress was completed using light-weight pumice rock fill and is generally stable in appearance, except for local runoff erosion near the west end (refer to Photos 1 and 5). Diverting the surface runoff flow could mitigate the surface erosion by piping the collected water away from the steep slope. Alternatively, the erodable slope could be reinforced by installing a geosynthetic erosion control mat made specifically for runoff conditions.

Evaluation of Ground Movement Data

The inclinometers in the slide mass have not shown movement since the slide area was re-graded. Refer to Photos 1 and 6 for locations of instrumentation groups. The inclinometers showed movements early during emergency construction. Refer to Figure 1 for a plot of inclinometer-measured ground displacement (SI 142 J, near the slide toe). This plot shows that the slide moved as viscous fluid from the ground surface down to a depth of approximately 25 feet, with an additional small increment of movement near the bottom of the inclinometer casing (depth range of 41 to 49 feet). The pavement above the headscarp does not show any signs of slide-movement cracks or scarp retrogression.

Survey monitoring data on the Hoffman's Jiffy Lube property was requested, but it appears that the data that was provided is incomplete. Monitoring points A-1 through A-10 and B-1 through B-12 were surveyed on July 6 and 17th, 2000. Monitoring points B-1 through B-8 were also surveyed on November 27th, 2000 (points B-9 through B-12 were disturbed and therefore could not be surveyed). On November 27th, new monitoring points were added, designated C-1 through C-4. Monitoring points D-1 through D-4 were surveyed on November 6, 14, and 22, 2000. The provided data shows that no significant ground movement was measured at the monitoring points on the dates cited herein.

We understand that survey monitoring has been performed along the powerline easement to the east of the slide. Survey stakes numbered 17 through 36 were evident on site. This monitoring data was requested but it has not been provided yet.

Evaluation of Groundwater Data

The piezometers within the slide mass show levels generally ranging from 0 to 10 feet below the ground surface. The shallower groundwater appears in boring B-16, above the original stream channel. It appears that the construction activity affected the groundwater pressures only slightly; resulting in 0 to +2 feet (water head) increase in the piezometric levels. The trends shown in the piezometer plots provided by NYSDOT

indicate that some of them were slow to reach equilibrium. The toe area piezometers (B-16) show that pore pressures are still near the ground surface and might have decreased slightly (0 to 2 feet). Observation of the slide toe area and counterberm indicates that groundwater seepage is not as evident as before, possibly because springs / wetland are now covered by counterberm fill material.

Instrumentation Monitoring Recommendations

The existing instrumentation is useful for monitoring long-term landslide conditions and performance of the mitigations. Most of the instruments are functioning.

Piezometers at the boring B-15 location (west central slide area) are not functioning; however, the instruments at boring locations B-5, B-12, and B-14 (SI #'s 142 I, E & J) should provide sufficient information for this location of the landslide (refer to Photo 6 for instrument locations). The inclinometers at boring locations B-4, B-5, and B-16 are in the centerline of the landslide and appear to be stable and capable of further monitoring.

We recommend that the inclinometers be monitored at least every three months over the next year, and more often if ground movements are suspected. The groundwater conditions might become elevated following spring recharge and periods of sustained precipitation (significant rainfall over several days). The piezometers should be monitored monthly and whenever extreme wet periods occur (unusually high amounts of sustained precipitation or peak stream flows). Alternatively, data loggers could be attached for continuous readings.

Evaluation of Adjacent Slopes

The December 9th reconnaissance included an evaluation of the hillside slopes on both sides of the landslide.

The ground slopes below the Hoffman's Jiffy Lube shop, and the Powerline easement to the east, exhibited less wetlands / seepage than what was observed in May and June. The survey monitoring data provided by the Jiffy Lube owner was limited to a few dates. There was no observable evidence of recent slide cracks or slumping. The counterberm and riprap placed at the stream bank should add resistance to the toe of this slope and make it more stable than before. Photos 7 through 10 show features at the east edge of the slide and at the slope below the Jiffy Lube. Data has not been received for the monitoring points in the Powerline easement. Photos 11 through 14 show slope features and improvements (riprap) made near the Powerline easement.

The slope below the Albany Medical Center (Corporate Finance Building) did not exhibit recent slide cracks or slumping. A small drainage channel travels down the slope, ending at the new counterberm fill where a small puddle forms. There were no significant seepage areas observed: apparently the counterberm fill has covered the wet areas observed in May and June. Survey monitoring data was not provided. The large counterberm and riprap placed at the relocated stream bank add resistance to the toe of this slope and make it more stable than before. Photos 1, 2, and 4 show the old slide features and the counterberm and buttress near the west edge of the slide. Photos 15 through 18 show construction features to the west of the slide toe, where the counterberm matches into the existing slope and accommodates a drainage ditch and the City of Albany construction to replace the water pipeline.

Summary

In summary, Delaware Avenue is not likely to be adversely affected by the landslide or the neighboring slopes. Continued instrumentation monitoring is advisable, but it need not be extensive.

We appreciate the opportunity to be of service to you on this mitigation project. Please call us at (503) 452-1200 if you have any questions.

Sincerely,

LANDSLIDE TECHNOLOGY

George Machan

By George Machan, PE

Senior Associate Engineer

Attachments:

Figure 1: Inclinometer Plot, location B-16

Photos 1 - 18

Limitations in the Use and Interpretation of This Geotechnical Report

Our professional services were performed, our findings obtained, and our recommendations prepared in accordance with generally accepted engineering principles and practices. This warranty is in lieu of all other warranties, either expressed or implied.

The geotechnical report was prepared for the use of the Owner in the design of the subject facility and should be made available to potential contractors and/or the Contractor for information on factual data only. This report should not be used for contractual purposes as a warranty of interpreted subsurface conditions such as those indicated by the interpretive boring and test pit logs, cross-sections, or discussion of subsurface conditions contained herein.

The analyses, conclusions and recommendations contained in the report are based on site conditions as they presently exist and assume that the exploratory borings, test pits, and/or probes are representative of the subsurface conditions of the site. If, during construction, subsurface conditions are found which are significantly different from those observed in the exploratory borings and test pits, or assumed to exist in the excavations, we should be advised at once so that we can review these conditions and reconsider our recommendations where necessary. If there is a substantial lapse of time between the submission of this report and the start of work at the site, or if conditions have changed due to natural causes or construction operations at or adjacent to the site, this report should be reviewed to determine the applicability of the conclusions and recommendations considering the changed conditions and time lapse.

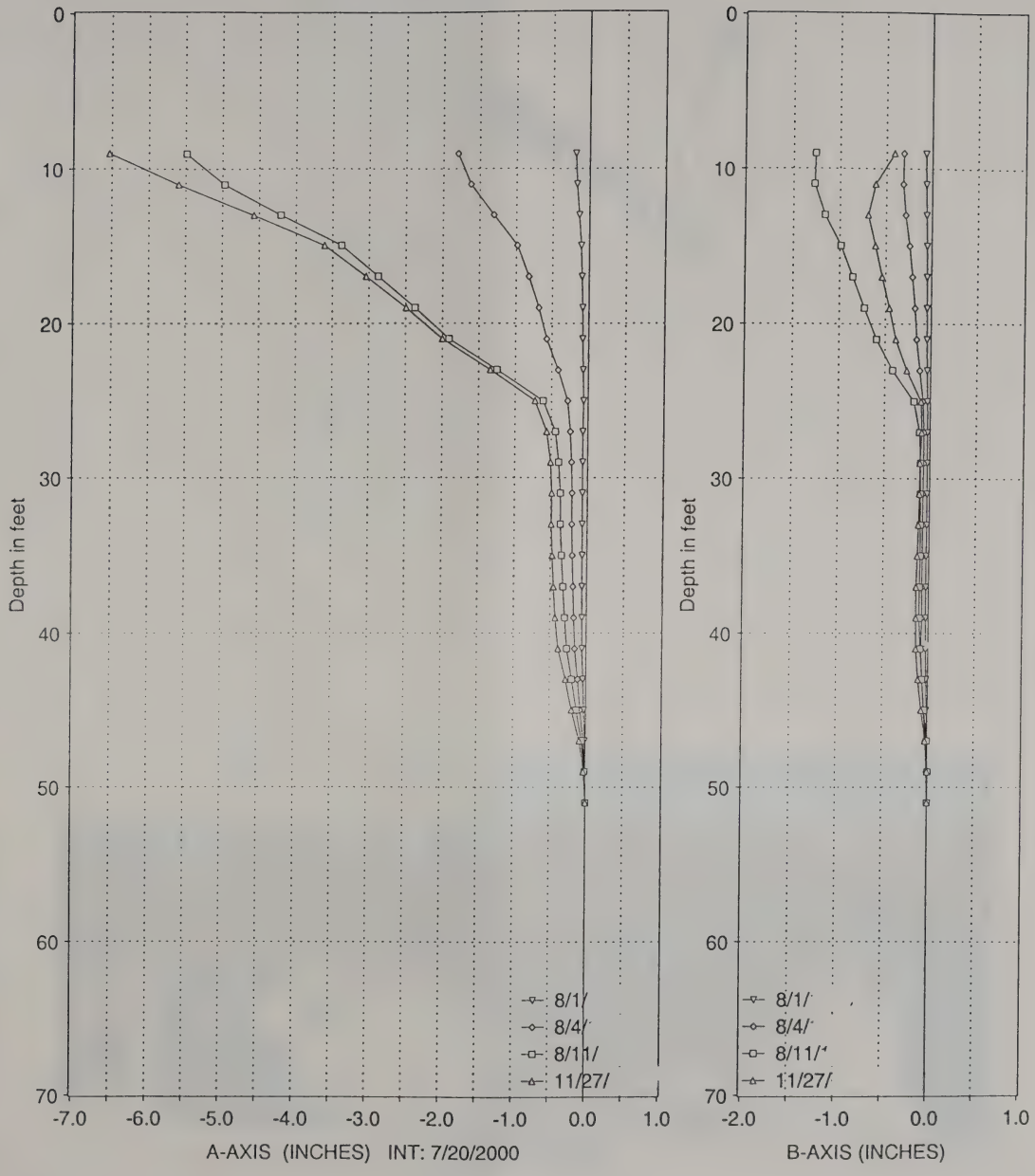
The Summary Boring Logs are our opinion of the subsurface conditions revealed by periodic sampling of the ground as the borings progressed. The soil descriptions and interfaces between strata are interpretive and actual changes may be gradual.

The boring logs and related information depict subsurface conditions only at these specific locations and at the particular time designated on the logs. Soil conditions at other locations may differ from conditions occurring at these boring locations. Also, the passage of time may result in a change in the soil conditions at these boring locations.

Groundwater levels often vary seasonally. Groundwater levels reported on the boring logs or in the body of the report are factual data only for the dates shown.

Unanticipated soil conditions are commonly encountered on construction sites and cannot be fully anticipated by merely taking soil samples, borings or test pits. Such unexpected conditions frequently require that additional expenditures be made to attain a properly constructed project. It is recommended that the Owner consider providing a contingency fund to accommodate such potential extra costs.

This firm cannot be responsible for any deviation from the intent of this report including, but not restricted to, any changes to the scheduled time of construction, the nature of the project or the specific construction methods or means indicated in this report; nor can our firm be responsible for any construction activity on sites other than the specific site referred to in this report.



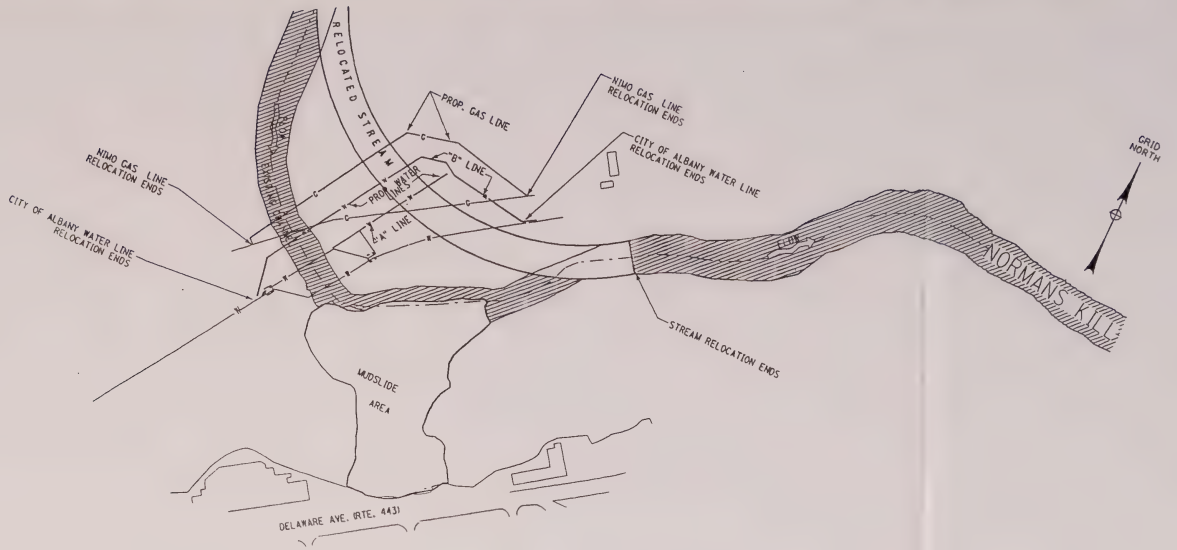
ROUTE 443 (DELAWARE AVENUE)
JOB: 1280

BORING B-16
CASING 142 J

INCLINOMETER PLOT
LOCATION B-16

FIG. 1

PHOTO 1: PANORAMA OF SLIDE AREA LOOK
DELAWARE AVENUE.



SITE PLAN

(FROM SHEET 10 OF CONSTRUCTION PLANS)

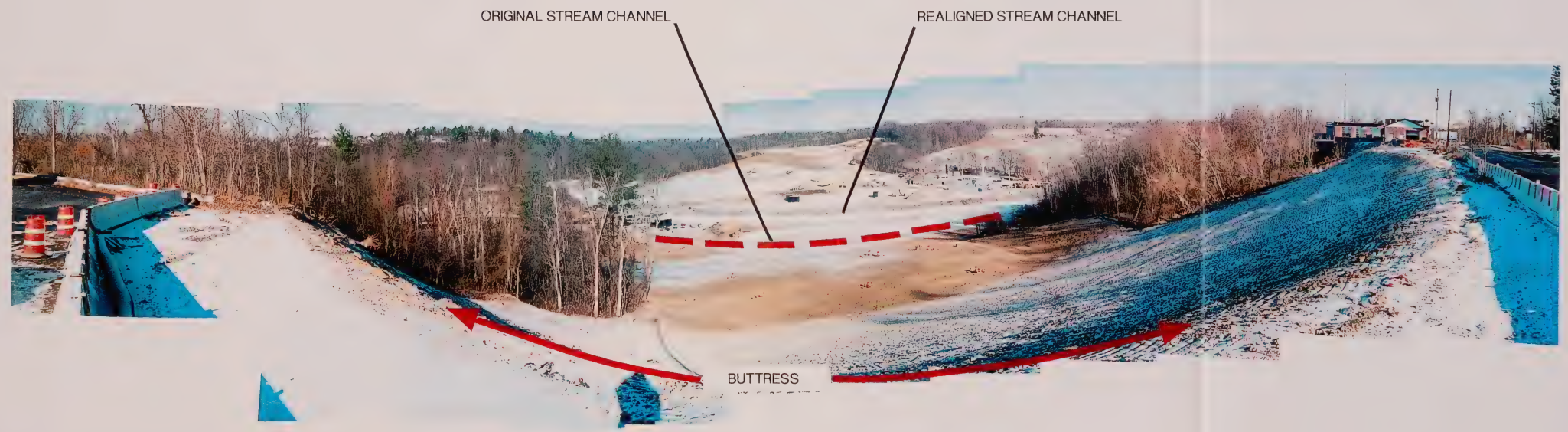


PHOTO 1: PANORAMA OF SLIDE AREA LOOKING NORTH FROM DELAWARE AVENUE.

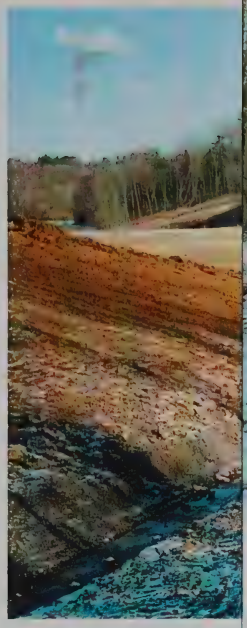


PHOTO 2: LOOKING E
TREED AREAS. NEW
SLIDE. THE FILL COV
AREAS.

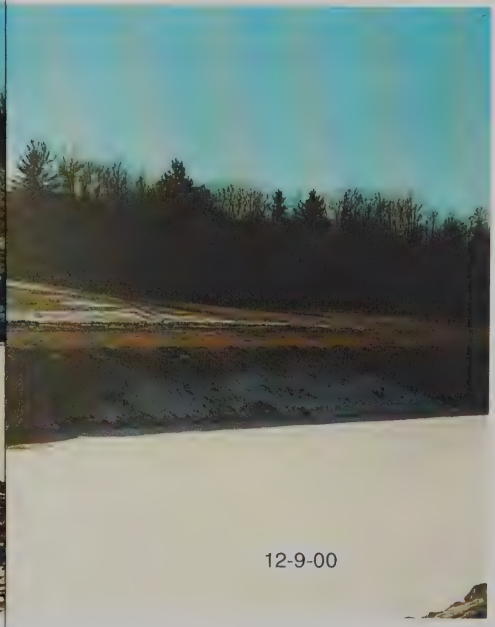


PHOTO 3: LOOKING SOU NDSLIDE.
NORMANS KILL STREAM ORMANS KILL STREAM
FLAT SLOPE FORMED BY
STREAM CHANNEL WAS
VEHICLES.

PHOTO 2: LOOKING EAST. NOTE OLD SLUMP FEATURES IN TREED AREAS. NEW COUNTER BERM FILL PLACED AT TOE OF SLIDE. THE FILL COVERS THE FORMER SEEPAGE AND WET AREAS.

PHOTO 3: LOOKING SOUTH AT LANDSLIDE. NEW REALIGNED NORMANS KILL STREAM CHANNEL IN FOREGROUND. NOTE THE FLAT SLOPE FORMED BY THE COUNTER BERM. THE ORIGINAL STREAM CHANNEL WAS LOCATED BEYOND THE PARKED VEHICLES.

PHOTO 4: LOOKING SOUTHWEST AT LANDSLIDE. COUNTERBERM AND NEW REALIGNED NORMANS KILL STREAM CHANNEL IN FOREGROUND.

PHOTO 5: LOOKING WEST AT SLOPE TO NORTH
MEDICAL CENTER. NOTE THE OLD SLIDE FEATU
AREA. HEADSCARP AREA WAS BUTTRESSED W
PUMICE, AND IS NOW COVERED WITH SOIL FOR
NOTE THE EROSION RILL NEAR THE WEST END
UPPERSLOPE, WHERE CONCENTRATED SURFA
OCCURING. CONSTRUCTION EQUIPMENT TO TH
WORKING ON THE ALBANY WATER PIPELINE.

GINAL STREAM CHANNEL

LANDSLIDE, LOOKING NORTH.
PPER ORANGE BARRELS, WHICH
OTECHNICAL INSTRUMENTS. THE
(#16) ARE LOCATED OVER THE
HANNEL.

PHOTO 5: LOOKING WEST AT SLOPE TO NORTH OF ALBANY MEDICAL CENTER. NOTE THE OLD SLIDE FEATURES IN TREED AREA. HEADSCARP AREA WAS BUTTRESSED WITH ROCK AND PUMICE, AND IS NOW COVERED WITH SOIL FOR REVEGETATION. NOTE THE EROSION RILL NEAR THE WEST END OF THE UPPERSLOPE, WHERE CONCENTRATED SURFACE RUNOFF IS OCCURING. CONSTRUCTION EQUIPMENT TO THE NORTH IS WORKING ON THE ALBANY WATER PIPELINE.

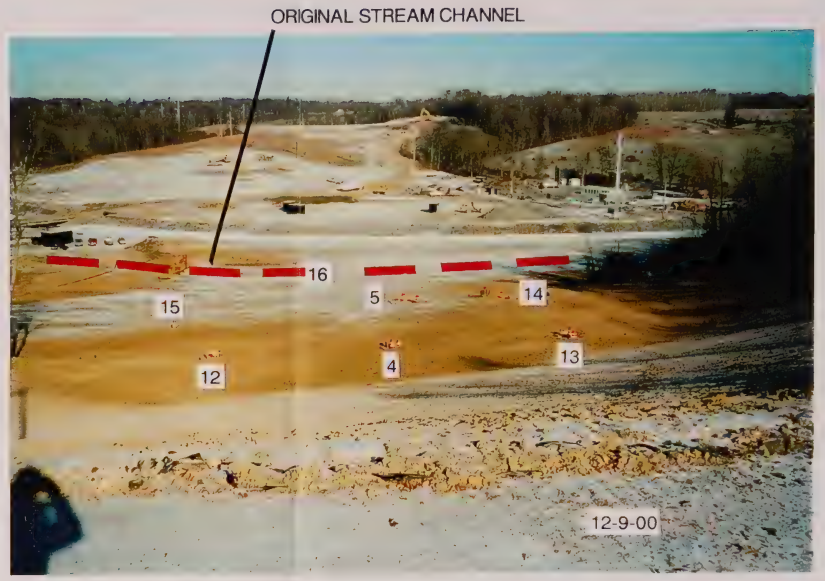


PHOTO 6: CENTRAL AREA OF LANDSLIDE, LOOKING NORTH. NOTE THE 3 MIDDLE AND 3 UPPER ORANGE BARRELS, WHICH MARK THE LOCATIONS OF GEOTECHNICAL INSTRUMENTS. THE LOWER MOST INSTRUMENTS (#16) ARE LOCATED OVER THE BURIED ORIGINAL STREAM CHANNEL.

PHOTO 7: LOOKING EAST. EAST SIDE OF LA
LUBE IN BACKGROUND. NOTE THE ANCIENT
IN TREED AREA AND COUNTER BERM ON LE

PHOTO 9: LOOKING EAST AT JIFFY LUBE. NOT PIPE FROM JIFFY LUBE
PIPE. ROCK FILL REPLACED THE WESTERLY S C. 9, 2000).
GABION WALL.

PHOTO 7: LOOKING EAST. EAST SIDE OF LANDSLIDE WITH JIFFY LUBE IN BACKGROUND. NOTE THE ANCIENT SLUMP FEATURES IN TREED AREA AND COUNTER BERM ON LEFT.

PHOTO 8: CLOSE UP VIEW OF SLOPE BELOW JIFFY LUBE.

PHOTO 9: LOOKING EAST AT JIFFY LUBE. NOTE DISCHARGE PIPE. ROCK FILL REPLACED THE WESTERLY SECTION OF GABION WALL.

PHOTO 10: LOOKING WEST. DISCHARGE PIPE FROM JIFFY LUBE IN FOREGROUND (NO WATER IN PIPE DEC. 9, 2000).

PHOTO 11: LOOKING SOUTHEAST. COUNTER B(B ON
AGAINST TOE OF LANDSLIDE (RIGHT FOREGRMENT, UPPER
POWERLINE EASEMENT IN LEFT CENTER. JIFF
RIGHT. REALIGNED NORMANS KILL STREAM IN
FOREGROUND.

PHOTO 13: WHITE PIPES (A ON PHOTOGRAPH) ONG STREAM
PIPELINE EASEMENT. NOTE NEW RIPRAP PROTERM FILL WITH
SIDES OF STREAM.

PHOTO 11: LOOKING SOUTHEAST. COUNTER BERM PLACED AGAINST TOE OF LANDSLIDE (RIGHT FOREGROUND). POWERLINE EASEMENT IN LEFT CENTER. JIFFY LUBE UPPER RIGHT. REALIGNED NORMANS KILL STREAM IN LEFT FOREGROUND.

PHOTO 13: WHITE PIPES (A ON PHOTOGRAPH) MARKING GAS PIPELINE EASEMENT. NOTE NEW RIPRAP PROTECTION BOTH SIDES OF STREAM.

PHOTO 12: LOOKING SOUTH AT WHITE PIPES (B ON PHOTOGRAPH) MARKING GAS PIPELINE EASEMENT, UPPER SLOPE. JIFFY LUBE PARKING LOT ON TOP.

PHOTO 14: LOOKING WEST. NEW RIPRAP ALONG STREAM CHANNEL IN FOREGROUND NEW COUNTER BERM FILL WITH RIPRAP IN CENTER PHOTO.

PHOTO 15: LOOKING EAST AT CULVERT NEAR A
EASEMENT.
H FROM CULVERT
OTE THE PIPELINE

PHOTO 17: LOOKING NORTHEAST. DRAINAGE D
CULVERT NEAR ALBANY WATER PIPELINE EASE
THROUGH NEW COUNTER BERM PLACED AGAIN
NE 'Y' FITTING.

PHOTO 15: LOOKING EAST AT CULVERT NEAR ALBANY WATER PIPELINE EASEMENT.

PHOTO 16: LOOKING EAST AT DRAINAGE DITCH FROM CULVERT NEAR ALBANY WATER PIPELINE EASEMENT. NOTE THE PIPELINE CONSTRUCTION NEAR BACKHOE.

PHOTO 17: LOOKING NORTHEAST. DRAINAGE DITCH FROM CULVERT NEAR ALBANY WATER PIPELINE EASEMENT FLOWS THROUGH NEW COUNTER BERM PLACED AGAINST SLIDE TOE.

PHOTO 18: LOOKING NORTH. ALBANY PIPELINE 'Y' FITTING.